REMARKS/ARGUMENTS

Claim Rejections – 35 U.S.C. § 112

Claims 1-5, 8-10, 13-20, and 22-29 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description and failing to comply with the enablement requirement.

Applicant has cancelled claims 1-5, 8-10, 13-20, and 22-29 and presents new claims 30-40 which comply with the written description and provide clearer enabling steps.

Claim Rejections – 35 U.S.C. § 103

Claims 1-3, 8-10, 14-18, 22-26 and 28-29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Heismann *et al.* ("Signal tracking and performance monitoring in multi-wavelength optical networks" in view of the admitted prior art and Rajagopal *et al.* (U.S. Patent NO. 7,120,118 B2).

Claims 4-5, 13, 19-20, and 27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Heismann in view of the admitted prior art, Rajagopal, and Sengupta *et al.* ("From network design to dynamic provisioning and restoration in optical cross-connect mesh networks: an architectural and algorithmic overview").

Applicant submits that:

(1) Heismann describes an optical-signal tracking system for an all-optical network using identifying tones.

The technique of using identifying tones for optical-signal tracking was well known at the time of filing the present application. Applicant's disclosure has acknowledged the prior art and provided a number of relevant references which employ the technique of using identifying

tones. Please see paragraphs [0016] to [0020] in publication US 2004/0120710 of the present application.

(2) Rajagopal discloses a method comprising identifying a current path (a planned path) for traffic traveling from a source node to a destination node and identifying a detour path (a planned alternate path) from the source node to the destination node traversing a detour node (please see the abstract and claim 1 in Rajagopal).

The main objective of the present invention is to provide a method and a system for detecting and identifying misrouted lightpaths in an optical network while Rajagopal is concerned with finding a path for a connection request. The distinctly different objectives result in distinctly different methods of implementation.

(3) The tutorial paper of Sengupta *et al.* elucidates the use of well known IP-based signaling protocols to establish light paths through an optical network.

Sengupta is concerned with establishing lightpaths and does not contemplate detecting or identifying misrouted paths.

Response to Arguments

On pages 14-15 of the office action, the Examiner indicated that the language of the claims does not limit the claims to misrouted paths. The Examiner suggested:

(1) Inclusion of claim language that captures the subject matter of misrouted paths into the body of the claims; and

(2) Providing active method steps or concrete apparatus elements.

Applicant appreciates the Examiner's suggestion and has rewritten the method claims as claims 30-40 which meet the above requirements.

The discussion below further clarifies the distinction of the method of the present

invention from the prior art.

The present invention

The invention as described in the specification of the present application provides a novel method of ensuring correct routing within an optical signal. The specification relies heavily on technical details, regarding the use of optical signatures, provided in previous US patents issued to the same assignee of the present application and incorporated by reference. The specification provides one example to illustrate the method. In the following, the invention is summarized and further illustrated with the help of another example, illustrated in Figures A, B, and C, in order to help distinguishing the invention from the prior art.

Consider a network (Figure A) of 25 nodes individually identified by the first 25 characters of the English alphabet and arranged in a lattice structure. At least one node has a Command-Line Interface (CLI). The network designer provisioned hundreds of lightpaths of which two are illustrated. A lightpath occupies a wavelength band traversing at least two nodes. The central wavelength in a wavelength band is denoted λ_k, where k is an arbitrary identifier of the central wavelength. Numerous lightpaths may use the same wavelength band as long as the lightpaths are spatially distinct. For example, each WDM link connecting respective two nodes may have the same predefined 32 wavelength bands of central wavelengths indexed as k=0 to k=31. However, lightpaths of the same wavelength band, each traversing a respective subset of links, do not interfere with each other if they are spatially segregated. Likewise, an optical node may switch several wavelength bands of the same central wavelength which are spatially distinguished according to their input ports and output ports.

The problem solved by the invention

A mistake in a routing table within any of the nodes could interchange two or more optical signals of the same central wavelength λ_k. For example, a first signal received at input port p_1 of an optical node, destined to output port q_1 of the optical node, and a second signal from input port p_2 of the optical node, destined to output port q_2 of the same optical node, may be erroneously interchanged so that the first signal is sent to output port q_2 and the second signal is sent to output port q_1. The destination of an optical signal is typically an electronic router (an

electronic switching node in general). An electronic router may verify correct delivery of an optical signal by examining the information content of the optical signal. However, in a case where an electronic router receives an unexpected optical signal, the electronic router cannot determine the path taken by the optical signal. When an expected optical signal has not been received, the electronic router cannot determine whether the optical signal has been misrouted or lost due to transmission problems.

The solution provided by the present invention

It is well known in the art to amplitude-modulate each optical signal with a unique low-frequency signature, without interfering with the information content (the payload) of the optical signals, in order to identify individual optical signals as the optical signals are switched through the network from one optical node to another. <u>Thus, the optical signals are identified in the optical domain without the need to examine their payload content</u>.

The method of identifying misrouted optical signals (i.e., misrouted lightpaths), according to the present invention, exploits the technique of using low-frequency distinctive signatures to identify individual optical signals. The method comprises four procedures: Walk; Trace; Local Discovery; and Global Discovery. The four procedures are summarized below. For brevity, hereinafter, the term "node" refers to an optical node.

Procedure "Walk" is based on reliable static data provided at each node. The output of procedure Walk is a *walk-sequence* of identifiers of nodes defining the route of a lightpath (an optical signal) under consideration. The walk-sequence is used as a reference sequence.

Procedure "Trace", illustrated in Figures 4 and 5 of the present application, produces a sequence of identifiers of nodes along an <u>**uninterrupted portion**</u> of an actual lightpath, having a target signature, succeeding the start node, *if any*, and/or a sequence of identifiers of nodes along an <u>**uninterrupted portion**</u> of the actual lightpath preceding the start node, *if any*. The combined result, a *Trace-sequence*, would be identical to the *Walk-sequence* if, and only if, there are no routing errors. Trace relies on lightpath information stored in a medium associated with each node which indicates, for each lightpath, an identifier of an upstream node, *if any*, and an identifier of a downstream node, *if any*, of each node determined to be on the lightpath.

If the Trace-sequence is in congruence with the Walk-sequence, then routing correctness is ascertained and there is no point in applying the Local-Discovery procedure or the Global-Discovery procedure, except – perhaps – for further confirmation of correctness.

Procedure "Local Discovery", illustrated in Figure 7 of the present application, is based on communicating, from an investigating Command Line Interface (CLI), with neighboring nodes. Local Discovery relies on topology information stored in a medium associated with each node in the network which indicates identifiers of all adjacent nodes (neighboring node) of each node. The start node communicates with all its neighboring (i.e., adjacent) nodes to identify a neighboring node which detects a specific optical signature. The neighboring nodes do the same to identify further nodes which detect the specific optical signature. Thus, the process continues to form a local-discovery set comprising identifiers of all nodes which detect the specific optical signal.

Procedure "Global Discovery" is based on communicating, from an investigating CLI, with each node in the network (i.e., broadcasting) to identify a subset of nodes that detect a specific signature identifying a lightpath of interest. Global discovery produces a set of nodes that actually receive an optical signal modulated by a specific signature identifying a lightpath under consideration. Global discovery relies on a list, stored in a medium associated with each node, of identifiers of all nodes in the network. Responses from optical nodes acknowledging presence of the specific signature may arrive at the CLI in an order that does not necessarily represent the sequence of nodes along the lightpath of interest.

In Figure 'A', a first lightpath is planned to traverse eight nodes {A,B,C,H,I,N,S,T}. A second lightpath is planned to traverse seven nodes {A, G, L, Q, V, W, X}. The two lightpaths have the same wavelength λ_k. The optical signal sent on first lightpath is modulated with a unique signature of index "1" and the lightpath is denoted as $\Lambda_k^{(1)}$. The optical signal sent along the second lightpath is modulated with another unique signature of index "2" and the lightpath is denoted as $\Lambda_k^{(2)}$. Applying, at CLI–B associated with node–B, procedure **Walk** and procedure **Trace** to $\Lambda_k^{(1)}$ yields identical results, indicating correct routing. Likewise, applying, CLI–V associated with node–V, procedure **Walk** and procedure **Trace** to $\Lambda_k^{(2)}$ yields identical results, indicating correct routing. This is the case where there are no lightpath-routing errors.

In Figure ‘B’, the above lightpath assignments were mixed up. The two lightpaths $\Lambda_k^{(1)}$ and $\Lambda_k^{(2)}$ originate from node–A. An administrator of node–A has erroneously interchanged the two lightpaths $\Lambda_k^{(1)}$ and $\Lambda_k^{(2)}$. Thus, the first lightpath $\Lambda_k^{(1)}$ ends up in node–X, and the second lightpath $\Lambda_k^{(2)}$ ends up in node–T. As well known in the art, a node <u>does not use signature information in routing</u> (switching) an optical signal. Rather, a node routes (switches) an optical signal according to (1) the central wavelength of the optical signal and (2) the incoming link (i.e., an input port receiving the optical signal).

The administrator of node-G, decides to determine if $\Lambda_k^{(2)}$ is properly routed. Procedure **Walk** is applied at CLI–G and yields a walk-sequence {A, G, L, Q, V, W, X}. Procedure **Trace** is applied at CLI–G to determine a trace sequence but yields only node-A because node-L does not detect the signature of $\Lambda_k^{(2)}$. Comparing the Walk-sequence and the Trace-sequence indicates that the trace sequence is incomplete. Procedure **Local Discovery** is then applied from CLI–G. It determines that neighboring node-B and node-H have detected the signature of $\Lambda_k^{(2)}$. CLI–G asks node–B and node–H to forward a Local-Discovery message to their respective neighbors. Node–B finds two neighbors, node-A and node-C, which have detected the signature of $\Lambda_k^{(2)}$ but the Local-Discovery message may already indicate beforehand that node–A is the originating node of the lightpath. Therefore, node–B forwards the Local-Discovery message to node–C. Node–H has two neighbors node–C and node–I which have detected the signature $\Lambda_k^{(2)}$. Node–C will however not respond because it has already responded to the request from node–B. Node–I responds to CLI–G and continues to discover node–N which discovers node–S which discovers node–T. <u>Finally, CLI–G knows how lightpath $\Lambda_k^{(2)}$ is misrouted</u>. All the node identifiers determined from procedure **Walk** are included in the result determined from the **Local-Discovery** procedure. Thus, CLI–G failed to get useful information from procedure **Trace**, but was successful with procedure **Local Discovery**; hence the more elaborate procedure **Global Discovery** is not needed.

Independently, CLI–V associated with node–V, applies procedure **Walk** and gets the walk-sequence {A, G, L, Q, V, W, X}, then applies procedure Trace and gets {Null} because neither of the upstream and downstream neighbors (node–W and node–Q) detects the signature

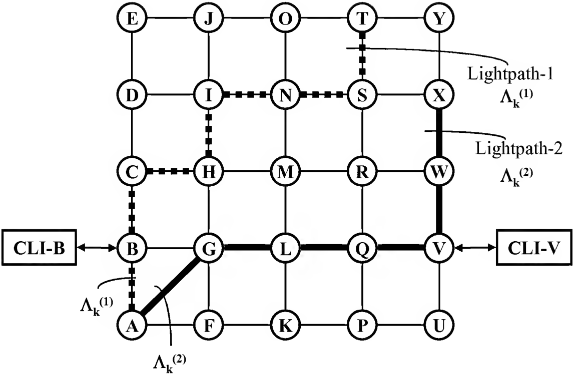
of $\Lambda_k^{(2)}$. CLI–V applies **Local Discovery** and gets {Null} because none of the neighbors (U, Q, and W) detects the signature of $\Lambda_k^{(2)}$. CLI–V had to apply **Global Discovery** and got the out-of-order but complete sequence {N, T, I, H, C, S, A, B}, which intersects the walk-sequence in only node-A.

CLI–X, associated with node–X, gets a walk-sequence {A, G, L, Q, V, W, X} and a Trace-sequence {Null}. CLI–X determines that further search is needed. CLI–X tries **Local Discovery** and receives an indication that node–S receives the signature of $\Lambda_k^{(2)}$. Hence, node-S is included in the Local-Discovery sequence. Node–S, being on the misrouted lightpath $\Lambda_k^{(2)}$, determines that node-N and node–T are also on the misrouted lightpath $\Lambda_k^{(2)}$. Node–T, which is on the misrouted lightpath $\Lambda_k^{(2)}$, determines that none of its neighbors, excluding of course node-S, is on the misrouted lightpath $\Lambda_k^{(2)}$. Node–T then determines that it is the destination node of the misrouted lightpath $\Lambda_k^{(2)}$. Node-N, being on the lightpath $\Lambda_k^{(2)}$, discovers node–I, which discovers node-H, which discovers node-C, which discovers node-B, which discovers node-A. CLI–X receives identifiers of all nodes along the misrouted lightpath $\Lambda_k^{(2)}$. CLI–X determines that all the information needed to identify the misrouted lightpath has been acquired and decides not to launch the time-consuming Global-Discovery procedure.

Figure C, which is self-explanatory, summarizes the discussion above regarding the lightpath-monitoring method of the invention.

Thus, the present invention provides an effective graduated method for detecting an incidence of lightpath misrouting and also identifies the nodes traversed by a misrouted lightpath. Applicant respectfully submits that no such capability is disclosed in the prior art.

Figure A



$\Lambda_k^{(s)}$: Wavelength channel k, occupying a wavelength band centered at wavelength of index k and modulated by a signature of index s

Lightpath-1 and lightpath-2 have the same central wavelength but are modulated by different signatures.

Figure B

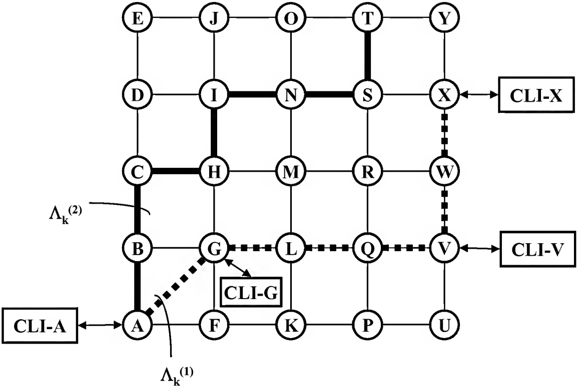
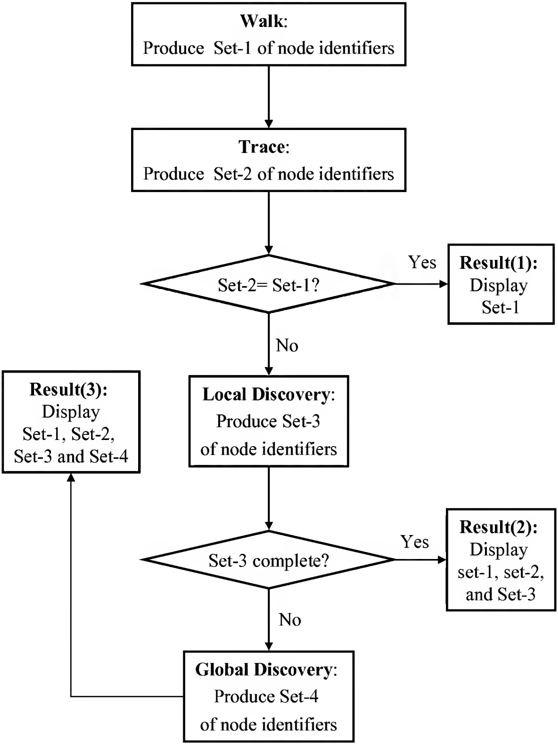

E
J
O
T
Y
D
I
N
S
X
CLI-X
C
H
M
R
W
$\Lambda_k^{(2)}$
B
G
L
Q
V
CLI-V
CLI-G
CLI-A
A
F
K
P
U
$\Lambda_k^{(1)}$

Figure C


Walk:
Produce Set-1 of node identifiers
Trace:
Produce Set-2 of node identifiers
Set-2= Set-1?
Yes
Result(1):
Display
Set-1
No
Result(3):
Display
Set-1, Set-2,
Set-3 and Set-4
Local Discovery:
Produce Set-3
of node identifiers
Set-3 complete?
Yes
Result(2):
Display
set-1, set-2,
and Set-3
No
Global Discovery:
Produce Set-4
of node identifiers

SUMMARY

Claims 30-40 are pending. Claims 1-29 have been cancelled

No new material has been added by way of the above amendments.

In view of the foregoing, early favorable consideration of the application is earnestly solicited.

Respectfully submitted,

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